Subject: Computer Science **Class: H2** **Saturday, 16th November, 2024**

Lesson: This lesson is about Deep Learning

A: Inquiry

Why do you think certain tasks, like understanding speech or playing complex games (e.g., chess), require more advanced approaches than traditional programming? Why might humans struggle to code explicit instructions for tasks like driving a car or identifying emotions in a photo? How could machines learn these at their own?

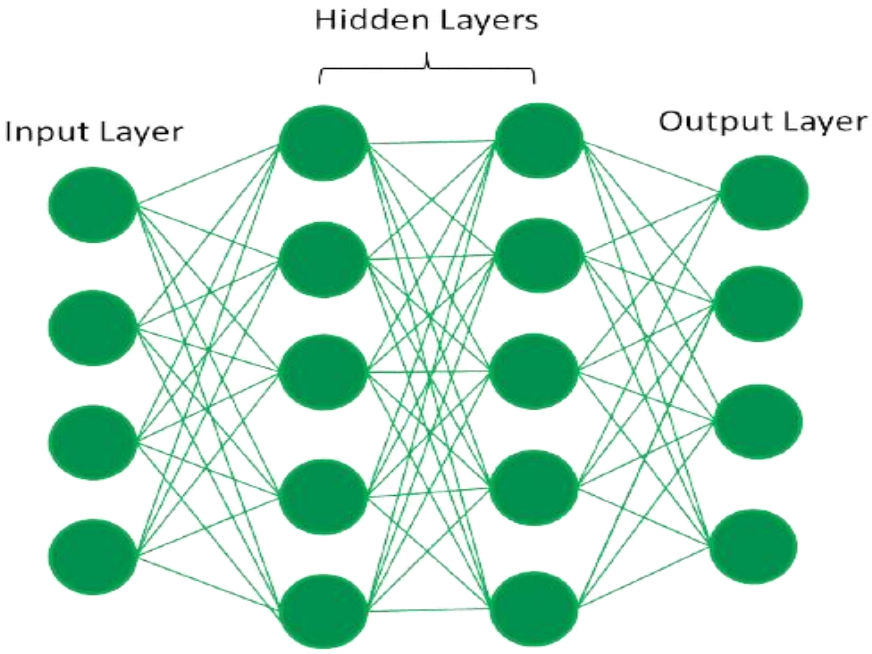
B: Information

What is Deep Learning?

By definition Deep learning is the branch of machine learning that is based on artificial neural network architecture. An artificial neural network or ANN uses layers of interconnected nodes called neurons that work together to process and learn from the input data.
In a fully connected Deep neural network, there is an input layer and one or more hidden layers connected one after the other. Each neuron receives input from the previous layer neurons or the input layer. The output of one neuron becomes the input to other neurons in the next layer of the network, and this process continues until the final layer produces the output of the network. The layers of the neural network transform the input data through a series of nonlinear transformations, allowing the network to learn complex representations of the input data.
Today Deep learning AI has become one of the most popular and visible areas of machine learning, due to its success in a variety of applications, such as computer vision, natural language processing, and Reinforcement learning.

Artificial neural networks

Artificial neural networks are built on the principles of the structure and operation of human neurons. It is also known as neural networks or neural nets. An artificial neural network's input layer, which is the first layer, receives input from external sources and passes it on to the hidden layer, which is the second layer. Each neuron in the hidden layer gets information from the neurons in the previous layer, computes the weighted total, and then transfers it to the neurons in the next layer. These connections are weighted, which means that the impacts of the inputs from the preceding layer are more or less optimized by giving each input a distinct weight. These weights are then adjusted during the training process to enhance the performance of the model.



Fully Connected Artificial Neural Network

Artificial neurons, also known as units, are found in artificial neural networks. The whole Artificial Neural Network is composed of these artificial neurons, which are arranged in a series of layers. The complexities of neural networks will depend on the complexities of the underlying patterns in the dataset whether a layer has a dozen units or millions of units. Commonly, Artificial Neural Network has an input layer, an output layer as well as hidden layers. The input layer receives data from the outside world which the neural network needs to analyze or learn about.

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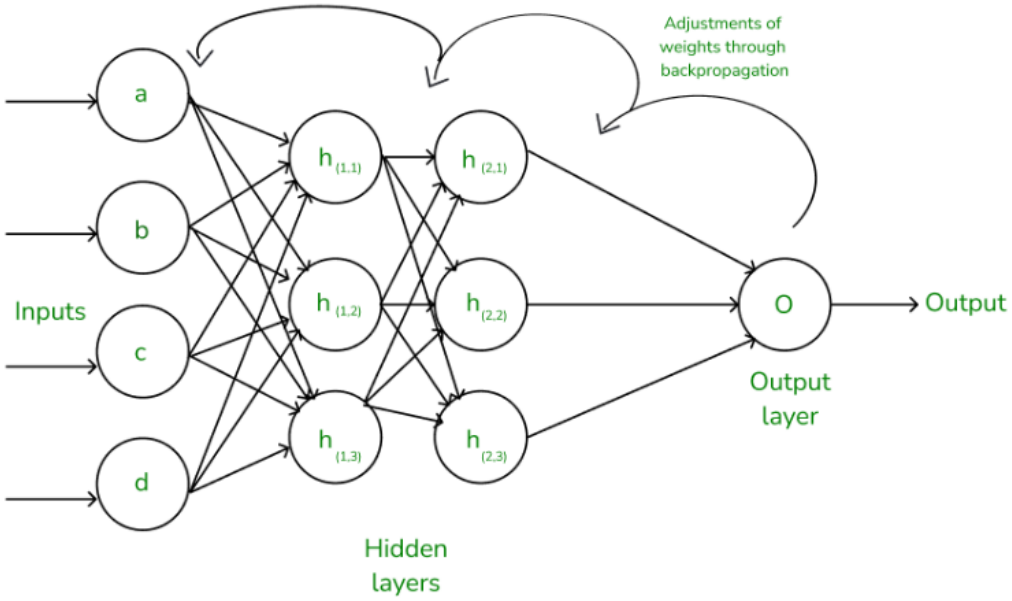
Units are linked to one another from one layer to another in the bulk of neural networks. Each of these links has weights that control how much one unit influences another. The neural network learns more and more about the data as it moves from one unit to another, ultimately producing an output from the output layer.

What is Back propagation?

Back propagation (short for "**Backward Propagation of Errors**") is a method used to train artificial neural networks. Its goal is to reduce the difference between the model's predicted output and the actual output by adjusting the weights and biases in the network



Difference between Machine Learning and Deep Learning:

Machine learning and deep learning AI both are subsets of artificial intelligence but there are many similarities and differences between them.

Machine Learning	Deep Learning
Apply statistical algorithms to learn the hidden patterns and relationships in the dataset.	Uses artificial neural network architecture to learn the hidden patterns and relationships in the dataset.
Can work on the smaller amount of dataset	Requires the larger volume of dataset compared to machine learning
Better for the low-label task.	Better for complex task like image processing, natural language processing, etc.
Takes less time to train the model.	Takes more time to train the model.
A model is created by relevant features which are manually extracted from images to detect an object in the image.	Relevant features are automatically extracted from images. It is an end-to-end learning process.
Less complex and easy to interpret the result.	More complex, it works like the black box interpretations of the result are not easy.
It can work on the CPU or requires less computing power as compared to deep learning.	It requires a high-performance computer with GPU.

Deep Learning Applications:

The main applications of deep learning AI can be divided into computer vision, natural language processing (NLP), and reinforcement learning.

1. Computer vision

The first Deep Learning application is Computer vision. In computer vision, Deep learning AI models can enable machines to identify and understand visual data. Some of the main applications of deep learning in computer vision include:

- **Object detection and recognition:** Deep learning model can be used to identify and locate objects within images and videos, making it possible for machines to perform tasks such as self-driving cars, surveillance, and robotics.
- **Image classification:** Deep learning models can be used to classify images into categories such as animals, plants, and buildings. This is used in applications such as medical imaging, quality control, and image retrieval.
- **Image segmentation:** Deep learning models can be used for image segmentation into different regions, making it possible to identify specific features within images.

2. Natural language processing (NLP)**:**

In Deep learning applications, second application is NLP. NLP, the Deep learning model can enable machines to understand and generate human language. Some of the main applications of deep learning in NLP include:

- **Automatic Text Generation** – Deep learning model can learn the corpus of text and new text like summaries, essays can be automatically generated using these trained models.
- **Language translation:** Deep learning models can translate text from one language to another, making it possible to communicate with people from different linguistic backgrounds.
- **Sentiment analysis:** Deep learning models can analyze the sentiment of a piece of text, making it possible to determine whether the text is positive, negative, or neutral. This is used in applications such as customer service, social media monitoring, and political analysis.
- **Speech recognition:** Deep learning models can recognize and transcribe spoken words, making it possible to perform tasks such as speech-to-text conversion, voice search, and voice-controlled devices.

3. Reinforcement learning:

In reinforcement learning, deep learning works as training agents to take action in an environment to maximize a reward. Some of the main applications of deep learning in reinforcement learning include:

- **Game playing:** Deep reinforcement learning models have been able to beat human experts at games such as Go, Chess, and Atari.
- **Robotics:** Deep reinforcement learning models can be used to train robots to perform complex tasks such as grasping objects, navigation, and manipulation.
- **Control systems:** Deep reinforcement learning models can be used to control complex systems such as power grids, traffic management, and supply chain optimization.

Challenges in Deep Learning

Deep learning has made significant advancements in various fields, but there are still some challenges that need to be addressed. Here are some of the main challenges in deep learning:

1. **Data availability**: It requires large amounts of data to learn from. For using deep learning it's a big concern to gather as much data for training.

2. **Computational Resources**: For training the deep learning model, it is computationally expensive because it requires specialized hardware like GPUs and TPUs.
3. **Time-consuming:** While working on sequential data depending on the computational resource it can take very large even in days or months.
4. I**nterpretability:** Deep learning models are complex, it works like a black box. it is very difficult to interpret the result.
5. **Overfitting:** when the model is trained again and again, it becomes too specialized for the training data, leading to overfitting and poor performance on new data.

Advantages of Deep Learning:

1. **High accuracy:** Deep Learning algorithms can achieve state-of-the-art performance in various tasks, such as image recognition and natural language processing.
2. **Automated feature engineering:** Deep Learning algorithms can automatically discover and learn relevant features from data without the need for manual feature engineering.
3. **Scalability:** Deep Learning models can scale to handle large and complex datasets, and can learn from massive amounts of data.
4. **Flexibility:** Deep Learning models can be applied to a wide range of tasks and can handle various types of data, such as images, text, and speech.
5. **Continual improvement:** Deep Learning models can continually improve their performance as more data becomes available.

Disadvantages of Deep Learning:

1. **High computational requirements:** Deep Learning AI models require large amounts of data and computational resources to train and optimize.
2. **Requires large amounts of labeled data**: Deep Learning models often require a large amount of labeled data for training, which can be expensive and time- consuming to acquire.
3. **Interpretability:** Deep Learning models can be challenging to interpret, making it difficult to understand how they make decisions.
   Overfitting: Deep Learning models can sometimes overfit to the training data, resulting in poor performance on new and unseen data.
4. **Black-box nature**: Deep Learning models are often treated as black boxes, making it difficult to understand how they work and how they arrived at their predictions.

- Please read what your text book says about machine learning (Topic 18.2.2 Page #. 440)
- Please watch the brief youtube videos
  - https://youtu.be/6M5VXKLf4D4 for Deep Learning
  - https://youtu.be/bfmFfD2RIcg for Neural Network

C: Synthesis/absorbing the information

Write your own summary notes in your notebook based upon above contents, your text book contents and what you saw on the videos.

D: Practising

Question 1: Deep learning is commonly used in real-world applications. Discuss how deep learning powers:

a. Autonomous vehicles (self-driving cars)

b. Facial recognition systems

c. Language translation tools (e.g., Google Translate)

Question 2: Deep learning can analyze large amounts of data, often used in medical diagnosis or personalized advertising.

a. What are the benefits of using deep learning in healthcare for disease detection and drug development?

b. What ethical challenges arise when deep learning is used in targeted advertising or surveillance?

Question 3: Deep learning is applied in industries like retail to predict customer behavior. Imagine you are designing a system to predict what products a customer is likely to purchase based on their browsing history.

a. What type of data would the system require?

b. How might deep learning models improve the accuracy of the predictions compared to traditional methods?

Feedback:

- Write your answers into an email message and send it to your teacher.
- If you have any questions about the topic, write all into the email to your teacher.

Students: *Please if you have any questions at all about this topic, anything you didn't understand, please send an email to your teacher.*

Class	Teachers' Name	Teachers' Abbreviation	Teachers' Email Address	Instructions
H2A	Adnan Hameed Qureshi	AHQ	Adnanhameedqureshi@gmail.com	H2A students will send their home assignments to their subject teacher (AHQ) for checking and getting feedback.
H2G	Seema Dawood	SSD	Seema_SSD_Sadiq@protonmail.com	H2G students will send their home assignments to their subject teacher (SSD) for checking and getting feedback.